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HYGIENIC CONTROL OF AIR IN RAILROAD TUNNELS DURING PASSAGE OF A LOCOMOTIVE

The inflow of carbon monoxide and sulfur dioxide in a tunnel after the passage of a locomotive can have toxic effects on engine, train, and maintenance personnel.

The content of tunnel gases depends on a great many factors: type and quality of fuel, boiler pressure, the train's speed, length and shape of the tunnel, frequency of train passage, meteorological conditions, etc.

Detailed study of the quantity and composition of gases given off by locomotives in roundhouses shows that as much as 2,000 kilograms of gas can be given off in an hour. With a gas temperature of 150-170 degrees, the carbon monoxide content was 0.5-1.5 percent, that of sulfur dioxide 0.2 percent, and of carbon dioxide 5-10 percent. On the road, the quantity and the composition of the gases can change considerably. In particular, the quantity of carbon monoxide can triple.

In tunnels, gases given off by the locomotive mix with air currents and the concentration diminishes. The faster the train speed, the less the danger of toxic concentration. When the train is at a standstill, the danger of toxic concentration rises sharply due to decrease or absence of air movement.

Detailed investigations of tunnel air were carried out by Grodzovskiy, D'yakov, Varishchev, Popov, Demidovich, and others. Under various conditions it was discovered that there was a carbon monoxide content of 0.02-0.061 percent (0.25-0.70 milligram per liter) in the locomotive cab; in the tunnel around the locomotive, from 0-0.05 percent (0-0.64 milligram per liter). Sulfur dioxide in the cab was from 0-0.035 (0-0.091 milligram per liter); in the tunnel around the locomotive, from 0-0.055 (0-1.45 milligram per liter).

The more dangerous conditions prevail when the locomotive skids, firing is improper, the train is standing still, or the natural ventilation of the tunnel is poor.

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The action of a train entering a tunnel is like that of a piston. It pushes out stale smoke and gas and draws in fresh air in its wake. The faster the train speed the better the ventilation. Increases of train speed in railroad transportation is a new factor in improving tunnel ventilation.

Simultaneous measurement of gases and determination of smoke concentration were carried out at five points in a 2,000-meter-long single-tracked graded tunnel. Temperature readings, humidity, and speed of air movement were taken and samples collected for analysis of carbon monoxide and sulfur dioxide content. As soon as the train left the tunnel, tests were made of the air in the breathing zone (1.5 meters from the ground); in 10 minutes the tests were repeated. The same procedure was followed for smoke concentration. The following conclusions were reached regarding the latter tests: (1) with a very heavy smoke concentration, the light from a flashlight could not be seen at a distance of one meter, (2) with a heavy concentration, the light from the closest electric lights would be distinguished, (3) with a moderate concentration, light from a series of electric lamps in the section could be distinguished, (4) with a weak concentration, the entrance could be seen, and (5) with an absence of smoke, the whole section was quite visible.

The natural movement of air in the tunnel in the absence of a train did not exceed 0.5 meters per second and only in isolated instances reached 2 meters per second. There was 80-95 percent humidity, with an outside temperature and humidity (October) of 11-20 degrees centigrade and 52-65 percent respectively. Depending on the speed of the train and the direction and speed of natural movement of air in the tunnel, smoke was in evidence over 0.3-0.7 of the tunnel's length.

Tests were made to determine the speed of air movement in the tunnel in front of and behind the train, and between the train and the tunnel wall.

Distribution of gas concentrations did not always correspond to the degree of smoke concentration. The gases mix with air and are often absorbed by the scale on the tunnel walls, and later released.

The carbon monoxide tests were made by the Reberg-Vinokurov method.

Tendency for gases to accumulate near the exit of the tunnel was noted; much depends on meteorological conditions and frequency of train passage. The question of maximum permissible concentration is important since it determines when maintenance men and inspectors may be present without danger.

The problem of sulfur dioxide will be taken up first since it is the simpler one. The sulfur content of coal varies from 0.7-7 percent. In coal from the Donets region, it constitutes 1.2-3 percent, in Anzherosudzhenskiy coal 0.4 percent, and in Kizelovskiy coal 6 percent.

According to Soviet legislation (OST 90014-39), the maximum permissible concentration of sulfur dioxide is 0.02 milligram per liter, and only when materials containing sulfur are being burned may the concentration be increased to 0.04 milligram per liter. The maximum permissible concentration in tunnels during passage of a train should be set at 0.04 milligram per liter. The concentration can also be reduced by proper supervision of the combustion process and by utilization of low-sulfur-content coal.

The concentration of carbon monoxide is usually the decisive factor in tunnel poisonings. The quantity of carboxyhemoglobin which forms when carbon monoxide is inhaled depends on the partial pressure of the oxygen and the carbon in the inhaled air; in addition, the duration of the gas's effect, the physical factors, the meteorological factor, and the individual characteristics

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of those working in the tunnel -- all play an important role.

In garages, the permissible content of carbon monoxide in rooms where workers spend the whole working day is 0.02 milligram per liter; in rooms where the worker stays only for 15 minutes the content may reach 0.2 milligram per liter (OST 90014-39).

The establishment by American researchers of the permissible concentration of carbon monoxide in a tunnel at 0.29-0.57 milligram per liter cannot be depended upon. According to observations of Soviet authors (Letavet, Smelyanskiy, Kosourov, and others), prolonged exposure to such concentration under working conditions can cause not only chronic acute poisoning.

There are various methods for artificial ventilation: the Sakkardo system, used in the Saint Gottard and other tunnels; the screen system, used in the Moffat tunnel; the shaft system, used in a Swiss tunnel and in the Moscow subway system; and the channel-shaft system, used in the Holland tunnel.

A comprehensive survey of conditions will indicate the system to be selected.

To protect crew and passengers, insulation of locomotives and cars is suggested (tight-fitting windows, doors, walls).

Gas-filtering apparatus should be provided for maintenance personnel.

Selection of the type of fuel, training of personnel, observation of rules for tunnel passage, and prohibition of trains over a maximum permissible weight will help to achieve a decrease in inflow of toxic gases. Installation of stronger type rails and spikes and limiting of maintenance work to periods when trains are not passing will protect maintenance workers.

The basic conditions for securing safe working conditions for train crews during tunnel passage are:

1. Use only special types of coal on tunnel sections of track.

2. Utilization of special types of coal must be assured by laboratory control. The engineer will be responsible for receipt and utilization of coal of the proper quality.

3. Locomotive section must work out rules for stoking boiler and train handling during tunnel passage.

4. Cabs must be sturdily built and have tightly closing doors and windows.

5. All locomotives must be provided with reserve receptacles to scoop up air before the engine enters the tunnel. Fresh air will be funneled by a special network to the engineer's cab while the train is in the tunnel.

6. The carbon monoxide content should not exceed 0.2 milligram per liter in the locomotive cab for any 15-minute period.

7. If a train is obliged to stop in a tunnel, engine and train crews will utilize antigas apparatus with which they must be provided.

8. When the train passes through a tunnel, maintenance workers must stand in the niches provided for that purpose and resume work only after that interval of time designated for the tunnel in question.

9. Tunnel ventilation should be so planned that 10-15 minutes after the train has passed, the concentration of carbon monoxide will reach 0.12 milligram per liter and after a half hour 0.03 milligram per liter.

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